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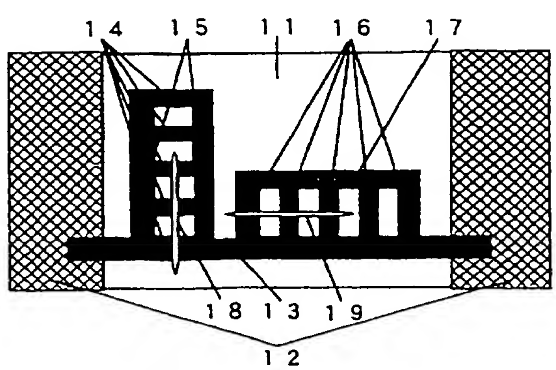
(54) Ladder-like resistor and method of manufacturing the same

(57) The present invention is directed towards a resistor which has higher load-, surge-, and pulse-resistant characteristics and is capable of having a resistance adjusted at a higher rate of precision.

A pair of electrodes 12 and a main resistance path 13 between the two electrodes 12 are mounted on a substrate 11. The main resistance path 13 is joined to a set of first rungs 14 which extend parallel to the main resistance path 13 and are joined with two first connecting paths 15 to form a first ladder-like resistance path for rough adjustment of the resistance which is connected to a part of the main resistance path 13. Also, a second ladder-like resistance path for fine adjustment of the resistance which comprises a set of second rungs 16 extending vertically from the main resistance path 13 and two second connecting paths 17 joining the second rungs 16 together is formed and connected to a part of the main resistance path 13. A combination of the two ladder-like resistance paths of a resistive body for rough and fine adjustments of the resistance permits a desired resistance to be set at a higher precision thus providing the higher load-, surge-, and pulse-resistant characteristics of a resultant resistor.

Fig 1



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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 4087

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 013, no. 435 (E-825), 28 September 1989 -& JP 01 164001 A (YAMATAKE HONEYWELL CO LTD), 28 June 1989 * abstract *	1,7	H01C17/242
Y		6,12,13, 15,16	
Y,D	JP 60 163402 A (NEC CORP) 26 August 1985 cited in the application	6,12,13, 15,16	
A	US 4 352 005 A (EVANS JONATHAN L ET AL) 28 September 1982 * abstract; claims; figures *	8,17	
A	US 4 647 906 A (NAYLOR JIMMY R ET AL) 3 March 1987 * figures 3,5 * * column 5, line 55 - column 6, line 34 *	1,2	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	ANONYMOUS: "Folded Pattern for Film Resistor with Trimmable Elements in Binary Sequence. September 1982." IBM TECHNICAL DISCLOSURE BULLETIN, vol. 25, no. 4, September 1982, pages 2003-2004, XP002081677 New York, US		H01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 October 1998	Wirner, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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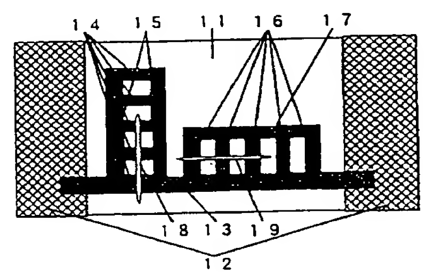
(57) The present invention is directed towards a resistor which has higher load-, surge-, and pulse-resistant characteristics and is capable of having a resistance adjusted at a higher rate of precision.

A pair of electrodes 12 and a main resistance path 13 between the two electrodes 12 are mounted on a substrate 11. The main resistance path 13 is joined to a set of first rungs 14 which extend parallel to the main resistance path 13 and are joined with two first connecting paths 15 to form a first ladder-like resistance path for rough adjustment of the resistance which is connected to a part of the main resistance path 13. Also, a second ladder-like resistance path for fine adjustment of the resistance which comprises a set of second rungs 16 extending vertically from the main resistance path 13 and two second connecting paths 17 joining the second rungs 16 together is formed and connected to a part of the main resistance path 13. A combination of the two ladder-like resistance paths of a resistive body for rough and fine adjustments of the resistance permits a desired resistance to be set at a higher precision thus providing the higher load-, surge-, and pulse-resistant characteristics of a resultant resistor.

Fig 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a resistor for use win an electronic apparatus and a method of making the same.

Description of Prior Art

Commonly, electrodes and a resistive body for a square chip resistor are produced in a combination by a thick-layer method including printing and baking steps or vapor deposition and sputtering method. The resistor body is then trimmed by laser to have a desired value of resistance. However, the resistor body when being trimmed by laser may be damaged along the trimmed edge by the heat of laser hence lowering its load or pulse characteristic. For compensation, the resistor body is provided locally with a ladder-like resistance path(s) across which the trimming is made to determine a desired resistance.

The conventional resistor having such ladder-like resistance paths will now be explained.

One example of the conventional ladder-like resistance path equipped resistor is disclosed in Japanese Patent Laid-open Publication No. S60-163402 as shown in a plan view of Fig.19. As shown, there are provided a substrate 1 made of alumina, electrodes 2 made of nickel-chromium and gold and located on both side ends of the substrate 1 to extend from the upper surface to the lower surface, and resistor bodies 3, 4, and 5 made of a tantalum thin film and located on the upper surface of the substrate 1 between the two electrodes 2. More specifically, denoted by 3 is a main resistance path while 4 and 5 are ladder-like resistance paths arranged in parallel to the main resistance path 3. The ladder-like resistance path 5 is greater in the cross section of the resistive body than the ladder-like resistance path 4. Denoted by 6 are slit grooves made by laser trimming for slitting the ladder-like resistance paths.

A method of making the conventional resistor is explained.

First, layer patterns of tantalum thin-film resistor body and nickel-chromium/gold electrode element are formed on the substrate 1 made mainly of 96% pure alumina with a known magnetron sputtering apparatus.

The resistive body and the electrodes are then shaped by a photo-etching technique and heated at 350°C for one hour.

This is followed by laser trimming the ladder-like resistance path 4 of the small resistive cross section for adjusting the resistance to a roughly desired value which can be shifted to a final, precise resistance of the resistor by trimming the large resistive cross section of the ladder-like resistance path 5.

Finally, the ladder-like resistance path 5 of which resistive cross section is greater than that of the ladder-like resistance path 4 hence allowing a small increase of the resistance when it is cut apart is trimmed by laser for fine adjustment to the precise resistance value. As the result, the resistor with the precise resistance will be produced.

As the resistive body pattern with the ladder-like resistance paths is being laser trimmed, its resistance can be changed to a precise value at steps. Also, as no current runs through the trimmed edge portions of the resistive body which have been affected by laser heat during the trimming, the resistor will be improved in the load-, surge- and pulse-resistant characteristics.

It is however necessary for fine adjustment to a precise resistance value in the arrangement of the conventional resistor to have the ladder-like resistance path formed greater in the resistive cross section than the main resistance path so that a change in the resistance is minimized when the ladder-like resistance path of the resistive body is trimmed. Hence, the resistive cross section of the ladder-like resistance path of the resistive body has to be increased considerably in relation to that of the main resistance path for determining a desired resistance value with tolerance of less than ±5 %. Particularly for producing small-sized tip resistors, the ladder-like resistance path should be arranged with as possible as a minimum distance between the rungs or a minimum number of the rungs since it is hardly adjusted to have a precise value of resistance by only means of the laser trimming. It has hence been desired to develop improved resistors which have ladder-like resistance paths provided substantially identical in the size of resistive cross section to the conventional ones but are adapted for having a desired resistance determined at a higher precision thus giving higher load-, surge-, and pulse-resistant characteristics.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a resistor arranged to have a desired resistance determined by highly precise adjustment thus providing higher load-, surge-, and pulse-resistant characteristics.

A resistor according to the present invention is provided having a resistive body composed of a first ladder-like resistance path arranged of which rungs for rough adjustment of the resistance extend in parallel to a main resistance path or a first resistance adjusting path which can be trimmed vertical to the main resistance path for adjustment of the resistance, and a second ladder-like resistance path arranged of which rungs for fine adjustment of the resistance extend vertical to the main resistance path or a second resistance adjusting path which can be trimmed in parallel to the main resistance path for adjustment of the resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view of a resistor according to a first

embodiment of the present invention;

Fig. 2 is a diagram explaining steps of producing the resistor shown in Fig. 1;

Fig. 3 is a plan view of a resistor according to a second embodiment of the present invention;

Fig. 4 is a diagram explaining steps of producing the resistor shown in Fig. 3;

Fig. 5 is a plan view of a resistor according to a third embodiment of the present invention;

Fig. 6 is a diagram explaining steps of producing the resistor shown in Fig. 5;

Fig. 7 is a plan view of a resistor according to a fourth embodiment of the present invention;

Fig. 8 is a diagram explaining steps of producing the resistor shown in Fig. 7;

Fig. 9 is a plan view of a resistor according to a fifth embodiment of the present invention;

Fig. 10 is a diagram explaining steps of producing the resistor shown in Fig. 9;

Fig. 11 is a plan view of a resistor according to a sixth embodiment of the present invention;

Fig. 12 is a diagram explaining steps of producing the resistor shown in Fig. 11;

Fig. 13 is a plan view of a resistor according to a seventh embodiment of the present invention;

Fig. 14 is a diagram explaining steps of producing the resistor shown in Fig. 13;

Fig. 15 is a plan view of a resistor according to an eighth embodiment of the present invention;

Fig. 16 is a diagram explaining steps of producing the resistor shown in Fig. 15;

Fig. 17 is a plan view of a resistor according to a ninth embodiment of the present invention;

Fig. 18 is a diagram explaining steps of producing the resistor shown in Fig. 17; and

Fig. 19 is a plan view of a conventional resistor.

DETAILED DESCRIPTION OF THE INVENTION

A resistor according to claim 1 of the present invention comprises: a substrate; a pair of electrodes mounted on both ends of an upper side of the substrate respectively; a main resistance path electrically connecting between the two electrodes; a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path; and a second ladder-like resistance path having a set of rungs thereof extending vertically from the main resistance path. For determining a desired value of resistance of the resistor, the first ladder-like resistance path is used for rough adjustment of the resistance and the second ladder-like resistance path is used for fine adjustment of the resistance. This allows the resistance of the resistor to be set to the desired value at a higher rate of precision. Also, trimmed regions of the resistive body injured by heat of the laser trimming are prevented from receiving any flow of current, hence contributing to the higher load-, surge-, and pulse-resistant characteristics of the resistor.

As defined in claim 2 of the present invention, two resistance paths between which the rungs of the second ladder-like resistance path are bridged in the resistor according to claim 1 are smaller in resistive cross section than the main resistance path. This causes a change in the resistance produced by trimming the second ladder-like resistance path for fine adjustment to be smaller than that of the resistive body defined in claim 1. Accordingly, more precise adjustment of the resistance will be made in addition to the advantage of claim 1.

As defined in claim 3 of the present invention, two resistance paths between which the rungs of the second ladder-like resistance path are bridged in the resistor according to claim 1 are higher in specific resistance than the main resistance path. This also causes a change in the resistance produced by trimming the second ladder-like resistance path for fine adjustment to be smaller than that of the resistor defined in claim 1. Accordingly, more precise adjustment of the resistance will be made in addition to the advantage of claim 1.

As defined in claim 4 of the present invention, the main resistance path in the resistor according to claim 1 is arranged in a zigzag so that all the rungs of the first and second ladder-like resistance paths extend in one direction. This allows the resistive body to be made compact in pattern size and save a space on the substrate for radiating the heat developed in the resistive body. Accordingly, the substrate will be utilized with high efficiency and the load-, surge-, and pulse-resistant characteristics of the resistor will be increased.

As defined in claim 5 of the present invention, the rungs of the second ladder-like resistance path in the resistor according to claim 1 are made of a conductive material. Since a change in the resistance produced by trimming the second ladder-like resistance path is proportional to a number of the trimmed conductive rungs, the resistance will be adjusted to a precise value with much ease as well as the advantage of claim 1.

A resistor according to claim 6 of the present invention comprises: a substrate; a pair of electrodes mounted on both ends of an upper side of the substrate respectively; a main resistance path electrically connecting between the two electrodes; a first resistance adjusting path connected to a part of the main resistance path in which a slit groove is scored vertical to the main resistance path; and a second resistance adjusting path connected to a part of the main resistance path in which a slit groove is scored parallel to the main resistance path. For determining a desired value of resistance of the resistor, the first resistance adjusting path is used for rough adjustment of the resistance and the second resistance adjusting path is used for fine adjustment of the resistance. This allows the resistance of the resistor to be set to the desired value at a higher rate of precision while the accuracy of the adjustment depends on the length of laser trimming. Also, as the resistive body is increased in resistive length, its trimmed regions injured by heat of the laser trimming produces no concentration of energy consumption,

hence ensuring the higher load-, surge-, and pulse-resistant characteristics of the resistor.

A resistor according to claim 7 of the present invention comprises: a substrate; a pair of electrodes mounted on both ends of an upper side of the substrate respectively; a main resistance path electrically connecting between the two electrodes; a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path; and a second resistance adjusting path connected to a part of the main resistance path in which a slit groove is scored parallel to the main resistance path. For determining a desired value of resistance of the resistor, the first ladder-like resistance path is used for rough adjustment of the resistance and the second resistance adjusting path is used for fine adjustment of the resistance. This allows the resistance of the resistor to be set to the desired value at a higher rate of precision while the accuracy of the adjustment depends on th length of the laser trimming. Also, trimmed regions of the resistive body injured by heat of the laser trimming are prevented in the first ladder-like resistance path from receiving any flow of current and in the second resistance adjusting path from concentration of energy consumption, hence ensuring the higher load-, surge-, and pulse-resistant characteristics of the resistor.

A resistor according to claim 8 of the present invention comprises: a substrate; a pair of electrodes mounted on both ends of an upper side of the substrate respectively; a main resistance path electrically arranged in a zigzag for connecting between the two electrodes; and a first resistance adjusting path connected to a part of the main resistance path in which two slit grooves are scored vertical to the main resistance path. This allows the resistive body to be minimized in pattern size in addition to the advantage of claim 6.

As defined in claim 9 of the present invention, the main resistance path in the resistor according to claim 6 is arranged in a zigzag so that the slit grooves in the first and second resistance adjusting paths extend in one direction. This allows the resistive body to be minimized in pattern size in addition to the advantage of claim 6.

As defined in claim 10 of the present invention, the main resistance path in the resistor according to claim 7 is arranged in a zigzag so that the rungs of the first ladder-like resistance path extend vertical to the slit groove in the second resistance adjusting path. This allows the resistive body to be minimized in pattern size in addition to the advantage of claim 7.

As defined in claim 11 of the present invention, the first and second resistance adjusting paths in the resistor according to claim 6 or 9 are greater in resistive cross section than the main resistance path. In addition to the advantage of claim 6 or 9, trimmed regions of the resistive body injured by heat of the laser trimming will be minimized in the concentration of energy consumption, hence ensuring the higher load-, surge-, and pulse-resistant characteristics of the resistor.

A method of making a resistor according to claim 12 of the present invention comprises the steps of: mounting a pair of electrodes on both ends of an upper side of a substrate respectively; mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path, and a second ladder-like resistance path having a set of rungs thereof extending vertically from the main resistance path; trimming the rungs of the first ladder-like resistance path from the main resistance path side for rough adjustment of the resistance; and trimming the rungs of the second ladder-like resistance path from one end for fine adjustment of the resistance. As the result, the resistor defined in claim 1, 2, or 4 can precisely be adjusted to a desired value of the resistance and undertake effectiveness of the production.

A method of making a resistor according to claim 13 of the present invention comprises the steps of: mounting a pair of electrodes on both ends of an upper side of a substrate respectively; mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path, and a set of rungs extending vertically from the main resistance path; joining the rungs extending vertically from the main resistance path with another resistive body which is higher in specific resistance than the resistive body to form a second ladder-like resistance path; trimming the rungs of the first ladder-like resistance path from the main resistance path side for rough adjustment of the resistance; and trimming the rungs of the second ladder-like resistance path from one end for fine adjustment of the resistance. As the result, the resistor defined in claim 3 can precisely be adjusted to a desired value of the resistance and undertake effectiveness of the production.

A method of making a resistor according to claim 14 of the present invention comprises the steps of: mounting a pair of electrodes on both ends of an upper side of a substrate respectively; mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, and a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path; mounting on the substrate a second resistive body which is arranged parallel to and independently connected to the main resistance path; mounting on the substrate a set of rungs of a conductor material which connect between the second resistive body and the main resistance path to form a second ladder-like resistance path; trimming the rungs of the first ladder-like resistance path from the main resistance path side for rough adjustment of the resistance; and trimming the rungs of the second lad-

der-like resistance path from one end for fine adjustment of the resistance. As the result, the resistor defined in claim 5 can precisely be adjusted to a desired value of the resistance and undertake effectiveness of the production.

A method of making a resistor according to claim 15 of the present invention comprises the steps of: mounting a pair of electrodes on both ends of an upper side of a substrate respectively; mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, a first resistance adjusting path connected to a part of the main resistance path and arranged to be scored vertical to the main resistance path for adjustment of the resistance, and a second resistance adjusting path connected to a part of the main resistance path and arranged to be scored parallel to the main resistance path for adjustment of the resistance; scoring the first resistance adjusting path from the main resistance path side vertically of the main resistance path for rough adjustment of the resistance; and scoring the second resistance adjusting path from one side parallelly of the main resistance path for fine adjustment of the resistance. As the result, the resistor defined in claim 6, 9, or 11 can precisely be adjusted to a desired value of the resistance and undertake effectiveness of the production.

A method of making a resistor according to claim 16 of the present invention comprises the steps of: mounting a pair of electrodes on both ends of an upper side of a substrate respectively; mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend parallel to the main resistance path, and a second resistance adjusting path connected to a part of the main resistance path and arranged to be scored parallel to the main resistance path for adjustment of the resistance; trimming the rungs of the first ladder-like resistance path from the main resistance path side for rough adjustment of the resistance; and scoring the second resistance adjusting path from one side parallelly of the main resistance path for fine adjustment of the resistance. As the result, the resistor defined in claim 7 or 10 can precisely be adjusted to a desired value of the resistance and undertake effectiveness of the production.

A method of making a resistor according to claim 17 of the present invention comprises the steps of: mounting a pair of electrodes on both ends of an upper side of a substrate respectively; mounting on the substrate a resistive body which comprises a main resistance path arranged in a zigzag to electrically connect between the two electrodes, and a first resistance adjusting path connected to a part of the main resistance path and arranged to be scored vertical to the main resistance path for adjustment of the resistance; scoring the first resistance adjusting path from the main resistance path side vertically of the main resistance path for rough adjustment of the resistance; and scoring again the first resistance adjusting path from the main resistance path side vertically of the main resistance path for fine adjustment of the resistance. As the result, the resistor defined in claim 8 can precisely be adjusted to a desired value of the resistance and undertake effectiveness of the production.

Preferred embodiment of the present invention will now be described referring to the accompanying drawings.

First Embodiment

Fig. 1 is a plan view of a resistor having a resistive body composed of ladder-like resistance paths showing a first embodiment of the present invention. There are shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is provided between the two electrodes 12 and arranged in parallel to a set of first rungs 14. The first rungs 14 are bridged between a couple of first connecting paths 15 joined to the main resistance path 13. Accordingly, the first rungs 14 and the two first connecting paths 15 constitute a first ladder-like resistance path of which rungs extend in parallel to the main resistance path 13. Also, a set of second rungs 16 extend vertically from the main resistance path 13. The second rungs 16 are joined by a second connecting path 17. Accordingly, the second rungs 16 and the second connecting path 17 constitute a second ladder-like resistance path of which rungs extend vertically from the main resistance path 13. The segments 13, 14, 15, 16, and 17 are members of a resistive body made of e.g. ruthenium oxide. Denoted by 18 is a first slit groove formed by laser trimming of the first ladder-like resistance path for rough adjustment of the resistance. Similarly, a second slit groove 19 is formed by laser trimming of the second ladder-like resistance path for fine adjustment of the resistance.

A method of making the resistor of the first embodiment of the present invention which has the resistive body composed of such two ladder-like resistance paths as explained above will be described in detail.

Fig. 2 illustrates steps of the method of making the resistor of the first embodiment of the present invention which has the resistive body composed of the two ladder-like resistance paths.

After the substrate 11 made mainly of 96% pure alumina is coated by printing with a pattern of silver glazing paste for the electrodes 12, it is passed in a conveyor belt oven and baked at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12, as shown in Fig. 2(a).

Then, a pattern of a resistive body which comprises a main resistance path 13 connecting the two elec-

trodes 12, a set of first rungs 14 arranged parallel to the main resistance path 13, a pair of first connecting paths 15 joining the first rungs 14 inbetween and connected to the main resistance path 13, a set of second rungs 16 extending vertically from the main resistance path 13, and a second connecting path 17 joining the second rungs 16 is printed with a ruthenium oxide glazing paste, as shown in Fig. 2(b), and baked in a conveyor belt oven at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by laser trimming the first rungs 14 from the main resistance path 13 side so that a roughly desired value of resistance which can be further adjusted to a final, precise resistance is obtained, as shown in Fig. 2(c).

Also, such a number of the second rungs 16 from one side are cut apart by laser trimming that the final, precise resistance is obtained, as shown in Fig. 2(d). As the result, a resistor having the final, precise resistance will be completed.

The laser trimming of a number of the rungs of the ladder-like resistance paths of the resistive body depends on a resistance level of the resistor.

The operation of the resistor of the first embodiment of the present invention is now explained with its resistive body having the ladder-like resistance paths.

When a given number of the first rungs 14 from the main resistance path 13 side are cut apart, the first ladder-like resistance path makes a detour and its resistance is significantly increased hence permitting rough adjustment of the resistance. When a particular number of the second rungs 16 are cut apart, the length of the second ladder-like resistance path remains nearly unchanged but the resistive cross section is slightly reduced. This allows the resistance of the second ladder-like resistance path to provide a very small increase. Also, the resistance increase is substantially proportional to the number of the trimmed rungs 19. Accordingly, the resultant resistance after the trimming can easily be predicted thus contributing to the fine adjustment. For example, the first ladder-like resistance path permits rough adjustment of the resistance with tolerances of -10% to -5% through trimming the first rungs 14 while the second ladder-like resistance path allows fine adjustment of the resistance with tolerances of ±1% ±2% through trimming the second rungs 16. As understood, the ladder-like resistance paths of the resistive body of the first embodiment are fabricated with much ease as well as permits adjustment of the resistance at a higher precision.

Furthermore, trimmed portions, which may be injured by heat generated by the laser trimming, of the ladder-like resistance paths of the resistive body of the first embodiment allow no flow of currents hence ensuring higher load-, surge-, and pulse-resistant characteristics of the resistor.

It is also possible for more precise adjustment to minimize the change of resistance by having the second connecting path 17 arranged smaller in the resistive cross section than the main resistance path 13.

Second Embodiment

Fig. 3 is a plan view of a resistor according to a second embodiment of the present invention. There are shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is provided between the two electrodes 12 and arranged in parallel to a set of first rungs 14. The first rungs 14 are bridged between a couple of first connecting paths 15 joined to the main resistance path 13. Accordingly, the first rungs 14 and the two first connecting paths 15 constitute a first ladder-like resistance path of which rungs extend in parallel to the main resistance path 13. Also, a set of second rungs 16 extend vertically from the main resistance path 13. The second rungs 16 are joined by a second connecting path 17. Accordingly, the second rungs 16 and the second connecting path 17 constitute a second ladder-like resistance path of which rungs extend vertically from the main resistance path 13. The segments 13, 14, 15, and 16 are members of a resistive body made of e.g. ruthenium oxide. The second connecting path 17 is a resistive body made of e.g. ruthenium oxide which is higher in the specific resistance than the main resistance path 13. Denoted by 18 is a first slit groove formed by laser trimming of the first ladder-like resistance path for rough adjustment of the resistance. Similarly, a second slit groove 19 is formed by laser trimming of the rungs 16 of the second ladder-like resistance path for fine adjustment of the resistance.

A method of making the resistor of the second embodiment of the present invention will be described in detail.

Fig. 4 illustrates steps of the method of making the resistor of the second embodiment of the present invention.

The method starts with coating the substrate 11 made mainly of 96% pure alumina with a printed pattern of silver glazing paste for the electrodes 12 and then passing it in a conveyor belt oven for baking at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12, as shown in Fig. 4(a).

Then, a pattern of a resistive body which comprises a main resistance path 13 connecting the two electrodes 12, a set of first rungs 14 arranged parallel to the main resistance path 13, a pair of first connecting paths 15 joining the first rungs 14 inbetween and connected to the main resistance path 13, and a set of second rungs 16 extending vertically from the main resistance path 13 is printed with a ruthenium oxide glazing paste, as shown in Fig. 4(b).

Subsequently, a pattern of the second connecting path 17 which joins the second rungs 16 together is printed with another ruthenium oxide paste of which

specific resistance is higher than that of the main resistance path 13, as shown in Fig. 4(c). The substrate 11 with the patterns printed thereon is baked in a conveyor belt oven at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by laser trimming the first rungs 14 from the main resistance path 13 side so that a roughly desired value of resistance which can further be adjusted to a final, precise resistance by trimming of the second rungs 16 is obtained, as shown in Fig. 4(d).

Also, such a number of the second rungs 16 from one side are cut apart by laser trimming that the final, precise resistance is obtained, as shown in Fig. 4(e). As the result, a resistor having the final, precise resistance will be completed.

The laser trimming of a number of the rungs of the ladder-like resistance paths of the resistive body depends on a resistance level of the resistor.

The operation of the resistor of the second embodiment of the present invention is now explained.

The combination of the two ladder-like resistance paths for rough and fine adjustment of the resistance in the resistor of the second embodiment, like the first embodiment, allows the resistance of the resistor to be adjusted to a desired value at a higher precision, hence providing improved load-, surge-, and pulse-resistant characteristics. In addition, the laser trimming of the rungs 16 of the second ladder-like resistance path produces a smaller change in the resistance than that of the first embodiment thus ensuring more precise adjustment.

Third Embodiment

Fig.5 is a plan view of a resistor according to a third embodiment of the present invention. There are shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is provided between the two electrodes 12 and arranged in such a zigzag so that the rungs of both a first and a second ladder-like resistance path extend in the same direction. Denoted by 14 are a set of first rungs arranged in parallel to the main resistance path 13 and bridged between a couple of first connecting paths 15 joined to the main resistance path 13. Accordingly, the first rungs 14 and the two first connecting paths 15 constitute the first ladder-like resistance path of which rungs extend in parallel to the main resistance path 13. Also, a set of second rungs 16 extend vertically from the main resistance path 13. The second rungs 16 are joined by a second connecting path 17. Accordingly, the second rungs 16 and the second connecting path 17 constitute the second ladder-like resistance path of which rungs extend vertically from the main resistance path 13. The segments 13, 14, 15, 16 and 17 are members of a resistive body made of e.g. ruthenium oxide. Denoted by 18 is a first slit groove formed by laser trimming of the first ladder-like resistance path for rough adjustment of the resistance. Similarly, a second slit groove 19 is formed by laser trimming of the rungs 16 of the second ladder-like resistance path for fine adjustment of the resistance.

A method of making the resistor of the third embodiment of the present invention will be described in detail.

Fig. 6 illustrates steps of the method of making the resistor of the third embodiment of the present invention.

The method starts with coating the substrate 11 made mainly of 96% pure alumina with a printed pattern of silver glazing paste for the electrodes 12 and then passing it in a conveyor belt oven for baking at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12, as shown in Fig. 6(a).

Then, a pattern of a resistive body which has the main resistance path 13 extending between the two electrodes 12 and the rungs 14 and 16 of the two ladder-like resistance paths arranged in the same direction is printed with a ruthenium oxide glazing paste, as shown in Fig. 6(b), and baked in a conveyor belt oven at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by laser trimming the first rungs 14 from the main resistance path 13 side so that a roughly desired value of resistance which can further be adjusted to a final, precise resistance by trimming of the second rungs 16 is obtained, as shown in Fig. 6(c).

Also, such a number of the second rungs 16 from one side are cut apart by laser trimming that the final, precise resistance is obtained, as shown in Fig. 6(d). As the result, a resistor having the final, precise resistance will be completed.

The laser trimming of a number of the rungs of the ladder-like resistance paths of the resistive body depends on a resistance level of the resistor.

The operation of the resistor of the third embodiment of the present invention is now explained.

The combination of the two ladder-like resistance paths for rough and fine adjustment of the resistance in the resistor of the third embodiment, like the first embodiment, allows the resistance of the resistor to be adjusted to a desired value at a higher precision, hence providing improved load-, surge-, and pulse-resistant characteristics. In addition, the resistor of this embodiment is identical in circuitry construction to that of the first embodiment but has an improved locational assignment of the two ladder-like resistance paths for highly efficient use of the limited area. As the result, the entire space required for the resistor of the third embodiment will be minimized contributing to the smaller size of the resistor.

Fourth Embodiment

Fig. 7 is a plan view of a resistor according to a fourth embodiment of the present invention. There are

shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is provided between the two electrodes 12 and arranged in parallel to a set of first rungs 14. The first rungs 14 are bridged between a couple of first connecting paths 15 joined to the main resistance path 13. Accordingly, the first rungs 14 and the two first connecting paths 15 constitute a first ladder-like resistance path of which rungs extend in parallel to the main resistance path 13. Also, a set of second rungs 16 extend vertically from the main resistance path 13. The second rungs 16 are joined by a second connecting path 17. Accordingly, the second rungs 16 and the second connecting path 17 constitute a second ladder-like resistance path of which rungs extend vertically from the main resistance path 13. The segments 13, 14, 15, and 17 are members of a resistive body made of e.g. ruthenium oxide. The second rungs 16 are conductors made of silver-paradium, copper, gold, or the like. Denoted by 18 is a first slit groove formed by laser trimming of the first ladder-like resistance path for rough adjustment of the resistance. Similarlly, a second slit groove 19 is formed by laser trimming of the rungs 16 of the second ladder-like resistance path for fine adjustment of the resistance.

A method of making the resistor of the fourth embodiment of the present invention will be described in detail.

Fig. 8 illustrates steps of the method of making the resistor of the fourth embodiment of the present invention.

The method starts with coating the substrate 11 made mainly of 96% pure alumina with a printed pattern of silver glazing paste to shape the electrodes 12 and the second rungs 16 and then passing it in a conveyor belt oven for baking at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12 and the second rungs 16, as shown in Fig. 8(a).

Then, a pattern of a resistive body which comprises a main resistance path 13 connecting the two electrodes 12, a set of first rungs 14 arranged parallel to the main resistance path 13, a pair of first connecting paths 15 joining the first rungs 14 inbetween and connected to the main resistance path 13, and a second connecting path 17 joining the second rungs 16 of the conductors together is printed with a ruthenium oxide glazing paste, as shown in Fig. 8(b) and baked in a conveyor belt oven at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by laser trimming the first rungs 14 from the main resistance path 13 side so that a roughly desired value of resistance which can further be adjusted to a final, precise resistance by trimming of the second rungs 16 is obtained, as shown in Fig. 8(c).

Also, such a number of the second rungs 16 from one side are cut apart by laser trimming that the final, precise resistance is obtained, as shown in Fig. 8(d). As the result, a resistor having the final, precise resistance will be completed.

The laser trimming of a number of the rungs of the ladder-like resistance paths of the resistive body depends on a resistance level of the resistor.

The operation of the resistor of the fourth embodiment of the present invention is now explained.

The combination of the two ladder-like resistance paths for rough and fine adjustment of the resistance in the resistor of the fourth embodiment, like the first embodiment, allows the resistance of the resistor to be adjusted to a desired value at a higher precision, hence providing improved load-, surge-, and pulse-resistant characteristics. Also, the change of resistance by laser trimming the rungs 16 of the second ladder-like resistance path is proportional to the number of the trimmed rungs 16 since the second rungs 16 are identical in the resistive cross section and will thus be increased in the accuracy ensuring more precise adjustment.

Fifth Embodiment

Fig. 9 is a plan view of a resistor according to a fifth embodiment of the present invention. There are shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is arranged to extend between the two electrodes 12. A first resistance adjusting path 20 is provided in which a first slit groove 18 is scored vertical to the main resistance path 13. A second resistance adjusting path 21 is provided in which a second slit groove 19 is scored parallel to the main resistance path 13. The first slit groove 18 is formed by laser trimming of the first resistance adjusting path 20 at a right angle to the main resistance path 13 for rough adjustment of the resistance. Similarlly, the second slit groove 19 is formed by laser trimming of the second resistance adjusting path in parallel to the main resistance path 13 for fine adjustment of the resistance. The members 13, 20, and 21 are made of a resistive body of e.g. ruthenium oxide.

A method of making the resistor of the fifth embodiment of the present invention will be described in detail.

Fig. 10 illustrates steps of the method of making the resistor of the fifth embodiment of the present invention.

The method starts with coating the substrate 11 made mainly of 96% pure alumina with a printed pattern of silver glazing paste for the electrodes 12 and then passing it in a conveyor belt oven for baking at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12, as shown in Fig. 10(a).

Then, a pattern of the resistive body which comprises a main resistance path 13 connecting the two electrodes 12, a first resistance adjusting path 20 in which the first slit groove 18 is scored vertical to the

main resistance path 13 for rough adustment of the resistance, and a second resistance adjusting path 21 in which the second slit groove 19 is scored parallel to the main resistance path 13 for fine adustment of the resistance is printed with a ruthenium oxide glazing paste, as shown in Fig. 10(b) and baked in a conveyor belt oven at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by scoring with a beam of laser the first resistance adjusting path 20 from the main resistance path 13 side so that a roughly desired value of resistance which can further be adjusted to a final, precise resistance by trimming of the second resistance adjusting path 21 is obtained, as shown in Fig. 10(c).

Also, the second resistance adjusting path 21 from one side is scored by laser trimming so that the final, precise resistance is obtained, as shown in Fig. 10(d). As the result, a resistor having the final, precise resistance will be completed.

The distance of the slit grooves scored in the resistance adjusting paths of the resistive body depends on a resistance level of the resistor.

The operation of the resistor of the fifth embodiment of the present invention is now explained.

As the first resistance adjusting path 20 has been scored from the main resistance path 13 side, its resistive length is increased hence allowing the resistance to be changed greatly for rough adjustment. When the second resistance adjusting path 21 has been laser trimmed from one side, its resistive cross section is changed while its length remains unchanged. Accordingly, the change in the resistance is small and substantially proportional to the length of the slit groove 19, whereby fine adjustment of the resistance will favorably be made.

For example, the first resistance adjusting path 20 is scored to have a rough value equal to -10% to -2% of the desired resistance and then, the second resistance adjusting path 21 is trimmed to have the desired resistance with allowances of ±0.1% to ±1%. As the result, the resistor of the fifth embodiment will be facilitated in fabrication and eased for more precise adjustment of the resistance.

Since the length of each resistance path is increased, the loss of electricity will be prevented from being concentrated about the slit grooves 18 and 19 or injured parts by heat of the laser contributing to the higher load-, surge-, and pulse-resistant characteristics of the resistor.

Also, when the slit groove 19 scored in the second resistance adjusting path 21 is located far from the main resistance path 13, the change of the resistance is minimized thus ensuring more precise adjustment of the resistance. Furthermore, the first and second resistance adjusting paths 20 and 21 are greater in the resistive cross section than the main resistance path 13, whereby the loss of electricity concentrated about the scored parts injured by heat of the laser will be minimized hence contributing to the higher load-, surge-, and pulse-resistant characteristics of the resistor.

Sixth Embodiment

Fig. 11 is a plan view of a resistor according to a sixth embodiment of the present invention. There are shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is provided between the two electrodes 12 and arranged in parallel to a set of first rungs 14. The first rungs 14 are bridged between a couple of first connecting paths 15 joined to the main resistance path 13. Accordingly, the first rungs 14 and the two first connecting paths 15 constitute a first ladder-like resistance path of which rungs extend in parallel to the main resistance path 13. Denoted by 18 is a first slit groove formed by laser trimming of the first ladder-like resistance path for rough adjustment of the resistance. There is provided a second resistance adjusting path 21 in which a second slit groove 19 is scored parallel to the main resistance path 13 for fine adjustment of the resistance. The second slit groove 19 is scored in parallel to the main resistance path 13 by laser trimming for decreasing the resistive cross section of the second resistance adjusting path 21. The members 13, 14, 15, and 21 are made of a resistive body of e.g. ruthenium oxide.

A method of making the resistor of the sixth embodiment of the present invention will be described in detail.

Fig. 12 illustrates steps of the method of making the resistor of the sixth embodiment of the present invention.

The method starts with coating the substrate 11 made mainly of 96% pure alumina with a printed pattern of silver glazing paste for the electrodes 12 and then passing it in a conveyor belt oven for baking at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12, as shown in Fig. 12(a).

Then, a pattern of a resistive body which comprises a main resistance path 13 connecting the two electrodes 12, a set of first rungs 14 arranged parallel to the main resistance path 13, a pair of first connecting paths 15 joining the first rungs 14 inbetween and connected to the main resistance path 13, and a second resistance adjusting path 21 having a second slit groove 19 scored therein in parallel to the main resistance path 13 is printed with a ruthenium oxide glazing paste, as shown in Fig. 12(b) and baked in a conveyor belt oven at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by laser trimming the first rungs 14 from the main resistance path 13 side so that a roughly desired value of resistance which can further be adjusted to a final, precise resistance by scoring the second resistance adjusting path 21 is obtained, as shown in Fig. 12(c).

Also, the second resistance adjusting path 21 is scored from one side by laser trimming so that the final, precise resistance is obtained, as shown in Fig. 12(d). As the result, a resistor having the final, precise resistance will be completed.

The laser trimming of a number of the rungs of the ladder-like resistance path and the determining a scoring distance of the resistance adjusting path depend on a resistance level of the resistor.

The operation of the resistor of the sixth embodiment of the present invention is now explained.

When the rungs 14 of the first ladder-like resistance path are laser trimmed by cutting a given number, the resistive length of the path is increased thus producing a great change in the resistance to permit rough adjustment. Also, as the second resistance adjusting path 21 has been scored in parallel to the main resistance path 13, its resistive cross section is changed while its length remains unchanged. Accordingly, the change in the resistance is small and substantially proportional to the length of the slit groove 19, whereby fine adjustment of the resistance will favorably be made.

For example, the first rungs 14 are trimmed to have a rough value equal to -10% to -2% of the desired resistance and then, the second resistance adjusting path 21 is scored to have the desired resistance with allowances of ±0.1% to ±1%. As the result, the resistor of the sixth embodiment will be facilitated in fabrication and eased for more precise adjustment of the resistance.

The trimmed rungs 14 of the ladder-like resistance path are cut apart with a beam of laser and may be injured by heat of the laser beam. The injured parts however are not loaded with any current and will allow the loss of electricity to be hardly concentrated, whereby the resistor will be increased in the load-, surge-, and pulse-resistant characteristics.

Also, when the slit groove 19 scored in the second resistance adjusting path 21 is located far from the main resistance path 13, the change of the resistance is minimized thus ensuring more precise adjustment of the resistance.

Seventh Embodiment

Fig. 13 is a plan view of a resistor according to a seventh embodiment of the present invention. There are shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is arranged in Z shape between the two electrodes 12 so that two slit grooves scored in their respective resistance adjusting paths extend in the same direction. A first resistance adjusting path 20 is provided in which a first slit groove 18 is scored vertical to the main resistance path 13. A second resistance adjusting path 21 is provided in which a second slit groove 19 is scored parallel to the main resistance path 13. The first slit groove 18 is formed by laser trimming of the first resistance adjusting path 20 at a right angle to the main resistance path 13 for rough adjustment of the resistance. Similarly, the second slit groove 19 is formed by laser trimming of the second resistance adjusting path in parallel to the main resistance path 13 for fine adjustment of the resistance. The members 13, 20, and 21 are made of a resistive body of e.g. ruthenium oxide.

A method of making the resistor of the seventh embodiment of the present invention will be described in detail.

Fig. 14 illustrates steps of the method of making the resistor of the seventh embodiment of the present invention.

The method starts with coating the substrate 11 made mainly of 96% pure alumina with a printed pattern of silver glazing paste for the electrodes 12 and then passing it in a conveyor belt oven for baking at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12, as shown in Fig. 14(a).

Then, a pattern of the resistive body which comprises a main resistance path 13 connecting the two electrodes 12, a first resistance adjusting path 20 in which the first slit groove 18 is scored vertical to the main resistance path 13 for rough adjustment of the resistance, and a second resistance adjusting path 21 in which the second slit groove 19 is scored parallel to the main resistance path 13 for fine adjustment of the resistance is printed with a ruthenium oxide glazing paste, as shown in Fig. 14(b), and baked in a conveyor belt oven at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by scoring with a beam of laser the first resistance adjusting path 20 from the main resistance path 13 side so that a roughly desired value of resistance which can further be adjusted to a final, precise resistance by trimming of the second resistance adjusting path 21 is obtained, as shown in Fig. 14(c).

Also, the second resistance adjusting path 21 from one side is scored by laser trimming so that the final, precise resistance is obtained, as shown in Fig. 14(d). As the result, a resistor having the final, precise resistance will be completed.

The distance of the slit grooves scored in the resistance adjusting paths of the resistive body depends on a resistance level of the resistor.

The operation of the resistor of the seventh embodiment of the present invention is now explained.

The combination of the two resistance adjusting paths for rough and fine adjustments of the resistance in the resistor of the seventh embodiment, like the fifth embodiment, allows the resistance of the resistor to be adjusted to a desired value at a higher precision, hence providing improved load-, surge-, and pulse-resistant characteristics. In addition, the resistor of this embodiment is identical in circuitry construction to that of the fifth embodiment but has an improved locational assignment of the two resistance adjusting paths for highly

efficient use of the limited area. As the result, the entire space required for the resistor of the seventh embodiment will be minimized contributing to the smaller size of the resistor.

Eighth Embodiment

Fig. 15 is a plan view of a resistor according to an eighth embodiment of the present invention. There are shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is arranged in a Z shape between the two electrodes 12 so that the rungs of a first ladder-like resistance path extend vertical to the slit groove in a second resistance adjusting path. The first rungs 14 of the first ladder-like resistance path are parallel to the main resistance path 13 and bridged between a couple of first connecting paths 15 joined to the main resistance path 13. Accordingly, the first rungs 14 and the two first connecting paths 15 constitute the first ladder-like resistance path of which rungs extend in parallel to the main resistance path 13. Denoted by 18 is a first slit groove formed by laser trimming of the first ladder-like resistance path for rough adjustment of the resistance. The second resistance adjusting path denoted at 21 is arranged in which the second slit groove denoted at 19 is scored parallel to the main resistance path 13 for fine adjustment of the resistance. The members 13, 14, 15, and 21 are made of a resistive body of e.g. ruthenium oxide.

A method of making the resistor of the eighth embodiment of the present invention will be described in detail.

Fig. 16 illustrates steps of the method of making the resistor of the eighth embodiment of the present invention.

The method starts with coating the substrate 11 made mainly of 96% pure alumina with a printed pattern of silver glazing paste to shape the electrodes 12 and the second rungs 16 and then passing it in a conveyor belt oven for baking at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12, as shown in Fig. 16(a).

Then, a pattern of a resistive body which comprises a main resistance path 13 connecting the two electrodes 12, a set of first rungs 14 arranged parallel to the main resistance path 13, a pair of first connecting paths 15 joining the first rungs 14 inbetween and connected to the main resistance path 13, and a second resistance adjusting path 21 having a second slit groove 19 scored therein in parallel to the main resistance path 13 is printed with a ruthenium oxide glazing paste, as shown in Fig. 16(b) and baked in a conveyor belt oven at 850°C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by laser trimming the first rungs 14 from the main resistance path 13 side so that a roughly desired value of resistance which can further be adjusted to a final, precise resistance by scoring the second resistance adjusting path 21 is obtained, as shown in Fig. 16(c).

Also, the second resistance adjusting path 21 is scored from one side by laser trimming so that the final, precise resistance is obtained, as shown in Fig. 16(d). As the result, a resistor having the final, precise resistance will be completed.

The laser trimming of a number of the rungs of the ladder-like resistance path and the determining a scoring distance of the resistance adjusting path depend on a resistance level of the resistor.

The operation of the resistor of the sixth embodiment of the present invention is now explained.

A combination of the first ladder-like resistance path for rough adjustment of the resistance and the second resistance adjusting paths for rough adjustment of the resistance in the resistor of the eighth embodiment, like the sixth embodiment, allows the resistance of the resistor to be adjusted to a desired value at a higher precision, hence providing improved load-, surge-, and pulse-resistant characteristics. In addition, the resistor of this embodiment is identical in circuitry construction to that of the sixth embodiment but has an improved locational assignment of the resistive body for highly efficient use of the limited area. As the result, the entire space required for the resistor of the eighth embodiment will be minimized contributing to the smaller size of the resistor.

Ninth Embodiment

Fig.17 is a plan view of a resistor according to a ninth embodiment of the present invention. There are shown a substrate 11 made of alumina, steatite, forsterite, beryllia, titania, glass, glass ceramic, or the like, and a pair of electrodes 12 made of silver, silver-paradium, copper, gold, or the like and located on both side ends of the substrate 11 to wrap the ends to the upper and lower sides. A main resistance path 13 is arranged in Z shape between the two electrodes 12. A resistance adjusting path 22 is provided in which a couple of slit grooves 18 and 19 are scored vertical to the main resistance path 13. The first slit groove 18 is formed by laser trimming of the resistance adjusting path 22 at a right angle to the main resistance path 13 for rough adjustment of the resistance. The second slit groove 19 is formed by laser trimming of the resistance adjusting path 22 at a right angle to the main resistance path 13 for fine adjustment of the resistance. The members 13 and 20 are made of a resistive body of e.g. ruthenium oxide.

A method of making the resistor of the ninth embodiment of the present invention will be described in detail.

Fig.18 illustrates steps of the method of making the resistor of the ninth embodiment of the present invention.

The method starts with coating the substrate 11 made mainly of 96% pure alumina with a printed pattern of silver glazing paste for the electrodes 12 and then passing it in a conveyor belt oven for baking at 850 C for 5 to 10 minutes, a total of 30 to 60 minutes, to cure the electrodes 12, as shown in Fig.18(a).

Then, a pattern of the resistive body which comprises a main resistance path 13 connecting in the Z shape between the two electrodes 12, and a resistance adjusting path 22 in which the slit grooves are scored vertical to the main resistance path 13 for adjustment of the resistance is printed with a ruthenium oxide glazing paste, as shown in Fig.18(b), and baked in a conveyor belt oven at 850 C for 5 to 10 minutes, a total of 30 to 60 minutes, for solidification.

This is followed by scoring with a beam of laser the resistance adjusting path 22 from the main resistance path 13 side to make the first slit groove 18 so that a roughly desired value of resistance which can further be adjusted to a final, precise resistance by scoring the second slit groove 19 is obtained, as shown in Fig.18(c).

Also, the resistance adjusting path 22 is scored adjacently to the first slit groove 18 again by laser trimming so that the final, precise resistance is obtained, as shown in Fig.18(d). As the result, a resistor having the final, precise resistance will be completed.

The length of the slit grooves scored in the first resistance adjusting path 22 of the resistive body depends on a resistance level of the resistor.

The operation of the resistor of the ninth embodiment of the present invention is now explained.

As the resistance adjusting path 22 has been trimmed from the main resistance path 13 side, its resistive length is increased hence allowing the resistance to be changed greatly for rough adjustment. When the resistance adjusting path 22 is laser trimmed again to have two slit grooves therein side by side, its resistive cross section is changed while its length remains unchanged. Accordingly, the change in the resistance is small and substantially proportional to the length of the second slit groove 19, whereby fine adjustment of the resistance will favorably be made.

For example, the resistance adjusting path 22 is scored two times, firstly to have a rough value equal to -10% to -2% of the desired resistance and secondly to have the desired resistance with allowances of ±0.1% to ±1%. As the result, the resistor of the ninth embodiment will be facilitated in fabrication and eased for more precise adjustment of the resistance.

Since the length of the resistive body is increased, the loss of electricity will be prevented from being concentrated about the slit grooves 18 or injured parts by heat of the laser contributing to the higher load-, surge-, and pulse-resistant characteristics of the resistor.

Although the electrodes and the resistive body of the prescribed embodiments are fabricated by printing and baking of the silver glazing paste and the ruthenium oxide glazing paste respectively, they may be made from other appropriate electrode and resistive materials of a paste form. Also, the patterns of electrode and resistive materials may be formed by common plating, vapor deposition, or sputtering process with equal success.

As set forth above, the present invention includes a given pattern of the resistive material which comprises a first ladder-like resistance path or resistance adjusting path for rough adjustment of the resistance and a second ladder-like resistance path or resistance adjusting path for fine adjustment of the resistance, hence providing a desired resistance at a higher precision. Also, after adjustment of the resistance by laser trimming, resultant injured parts of the resistive body produced by heat of the laser trimming are prevented from unwanted concentrated consumption of electricity thus allowing the resistor to have higher load-, surge-, and pulse-resistant characteristics.

In addition, making the corner of the zigzag of the main resistance path round reduces the concentration of energy consumption at the corner, hence improving the load-, surge- and pulse-resistant characteristics.

Claims

1. A resistor comprising:

    a substrate;
    a pair of electrodes mounted on both ends of an upper side of the substrate respectively;
    a main resistance path electrically connecting between the two electrodes;
    a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path; and
    a second ladder-like resistance path having a set of rungs thereof extending vertically from the main resistance path.

2. A resistor according to claim 1, wherein two resistance paths between which the rungs of the second ladder-like resistance path are bridged are smaller in resistive cross section than the main resistance path.

3. A resistor according to claim 1, wherein two resistance paths between which the rungs of the second ladder-like resistance path are bridged are higher in specific resistance than the main resistance path.

4. A resistor according to claim 1, wherein the main resistance path is arranged in a zigzag so that all the rungs of the first and second ladder-like resistance paths extend in one direction.

5. A resistor according to claim 1, wherein the rungs of the second ladder-like resistance path are made of a conductor material.

6. A resistor comprising:

a substrate;
a pair of electrodes mounted on both ends of an upper side of the substrate respectively;
a main resistance path electrically connecting between the two electrodes;
a first resistance adjusting path connected to a part of the main resistance path in which a slit groove is scored vertical to the main resistance path; and
a second resistance adjusting path connected to a part of the main resistance path in which a slit groove is scored parallel to the main resistance path.

7. A resistor comprising:

a substrate;
a pair of electrodes mounted on both ends of an upper side of the substrate respectively;
a main resistance path electrically connecting between the two electrodes;
a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path; and
a second resistance adjusting path connected to a part of the main resistance path in which a slit groove is scored parallel to the main resistance path.

8. A resistor comprising:

a substrate;
a pair of electrodes mounted on both ends of an upper side of the substrate respectively;
a main resistance path electrically arranged in a zigzag for connecting between the two electrodes; and
a resistance adjusting path connected to a part of the main resistance path in which two slit grooves are scored vertical to the main resistance path.

9. A resistor according to claim 6, wherein the main resistance path is arranged in a zigzag so that the slit grooves in the first and second resistance adjusting paths extend in one direction.

10. A resistor according to claim 7, wherein the main resistance path is arranged in a zigzag so that the rungs of the first ladder-like resistance path extend vertical to the slit groove in the second resistance adjusting path.

11. A resistor according to claim 6 or 9, wherein the first and second resistance adjusting paths are greater in resistive cross section than the main resistance path.

12. A method of making a resistor comprising the steps of:

mounting a pair of electrodes on both ends of an upper side of a substrate respectively;
mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path, and a second ladder-like resistance path having a set of rungs thereof extending vertically from the main resistance path;
trimming the rungs of the first ladder-like resistance path from the main resistance path side for rough adjustment of the resistance; and
trimming the rungs of the second ladder-like resistance path from one end for fine adjustment of the resistance.

13. A method of making a resistor comprising the steps of:

mounting a pair of electrodes on both ends of an upper side of a substrate respectively;
mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend in parallel to the main resistance path, and a set of rungs extending vertically from the main resistance path;
joining the rungs extending vertically from the main resistance path with another resistive body which is higher in specific resistance than the resistive body to form a second ladder-like resistance path;
trimming the rungs of the first ladder-like resistance path from the main resistance path side for rough adjustment of the resistance; and
trimming the rungs of the second ladder-like resistance path from one end for fine adjustment of the resistance.

14. A method of making a resistor comprising the steps of:

mounting a pair of electrodes on both ends of an upper side of a substrate respectively;
mounting on the substrate a resistive body which comprizes a main resistance path electrically connecting between the two electrodes, and a first ladder-like resistance path connected to a part of the main resistance path so

that a set of rungs thereof extend in parallel to the main resistance path;

mounting on the substrate a second resistive body which is arranged parallel to and independently connected to the main resistance path;

mounting on the substrate a set of rungs of a conductor material which connect between the second resistive body and the main resistance path to form a second ladder-like resistance path;

trimming the rungs of the first ladder-like resistance path from the main resistance path side for rough adjustment of the resistance; and

trimming the rungs of the second ladder-like resistance path from one end for fine adjustment of the resistance.

15. A method of making a resistor comprising the steps of:

mounting a pair of electrodes on both ends of an upper side of a substrate respectively;

mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, a first resistance adjusting path connected to a part of the main resistance path and arranged to be scored vertical to the main resistance path for adjustment of the resistance, and a second resistance adjusting path connected to a part of the main resistance path and arranged to be scored parallel to the main resistance path for adjustment of the resistance;

scoring the first resistance adjusting path from the main resistance path side vertically of the main resistance path for rough adjustment of the resistance; and

scoring the second resistance adjusting path from one side parallelly of the main resistance path for fine adjustment of the resistance.

16. A method of making a resistor comprising the steps of:

mounting a pair of electrodes on both ends of an upper side of a substrate respectively;

mounting on the substrate a resistive body which comprises a main resistance path electrically connecting between the two electrodes, a first ladder-like resistance path connected to a part of the main resistance path so that a set of rungs thereof extend parallel to the main resistance path, and a second resistance adjusting path connected to a part of the main resistance path and arranged to be scored parallel to the main resistance path for adjustment of the resistance;

trimming the rungs of the first ladder-like resistance path from the main resistance path side for rough adjustment of the resistance; and

scoring the second resistance adjusting path from one side parallelly of the main resistance path for fine adjustment of the resistance.

17. A method of making a resistor comprising the steps of:

mounting a pair of electrodes on both ends of an upper side of a substrate respectively;

mounting on the substrate a resistive body which comprises a main resistance path arranged in a zigzag to electrically connect between the two electrodes, and a resistance adjusting path connected to a part of the main resistance path and arranged to be scored vertical to the main resistance path for adjustment of the resistance;

scoring the resistance adjusting path from the main resistance path side vertically of the main resistance path for rough adjustment of the resistance; and

scoring again the resistance adjusting path from the main resistance path side vertically of the main resistance path for fine adjustment of the resistance adjacently to the slit groove produced in said rough adjustment of the resistance.

18. A resistor according to claim 4, 8, 9 or 10, wherein the corner of said zigzag of said main resistance path is round.

Fig 1

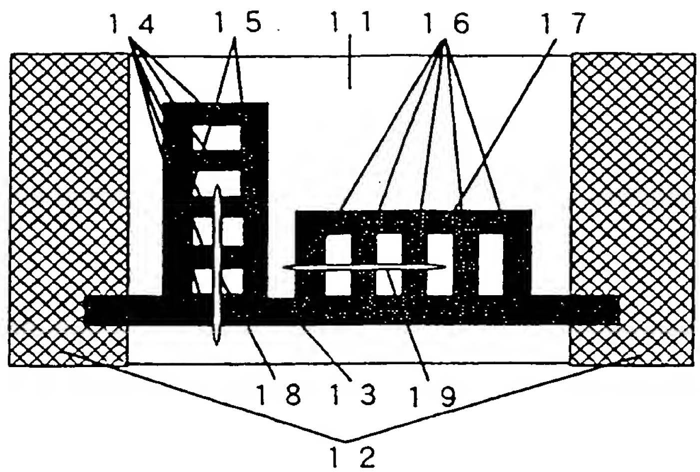


Fig 2

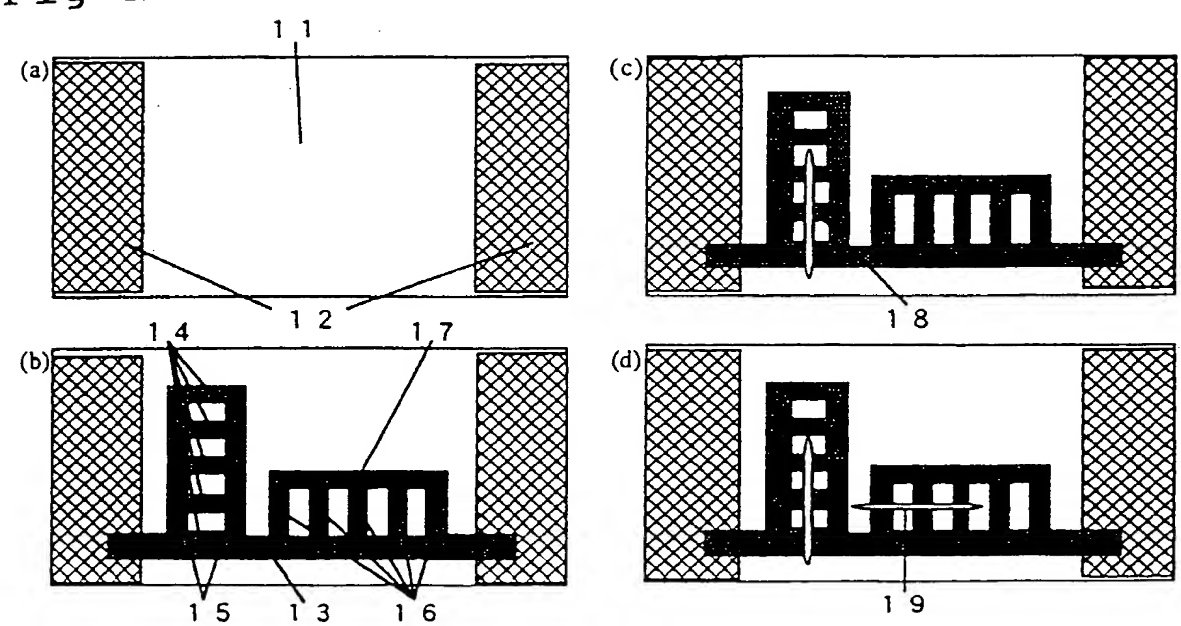


Fig 3

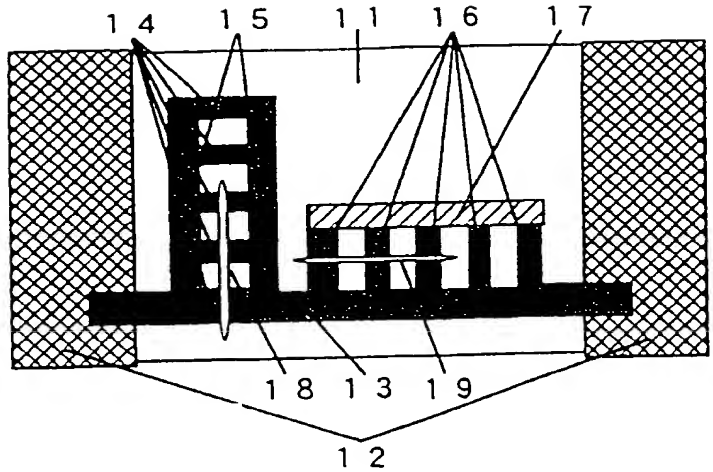


Fig 4

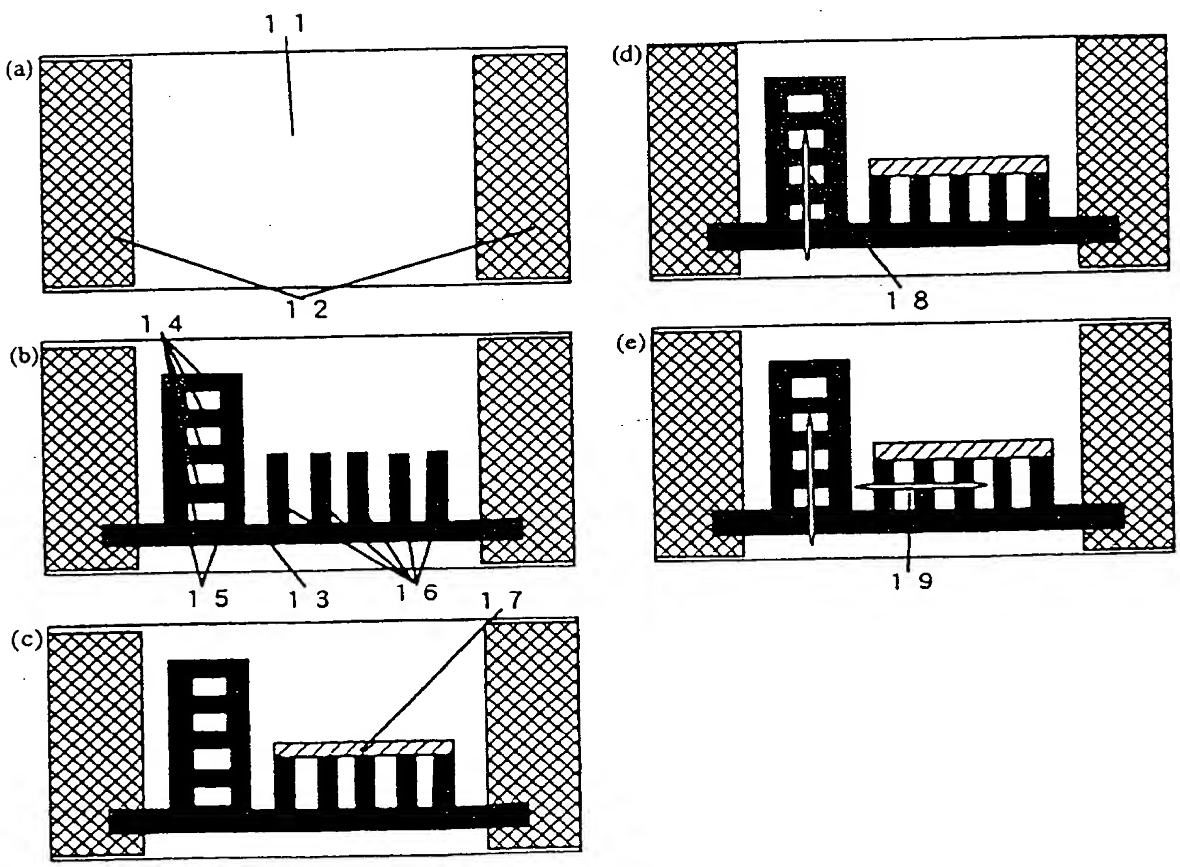
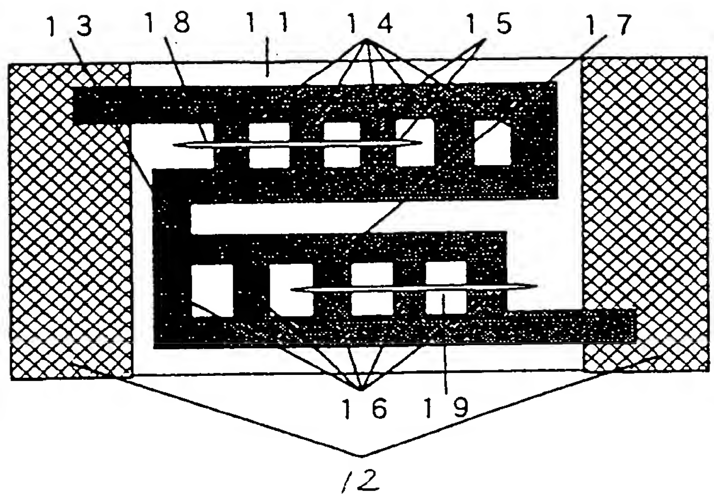


Fig 5



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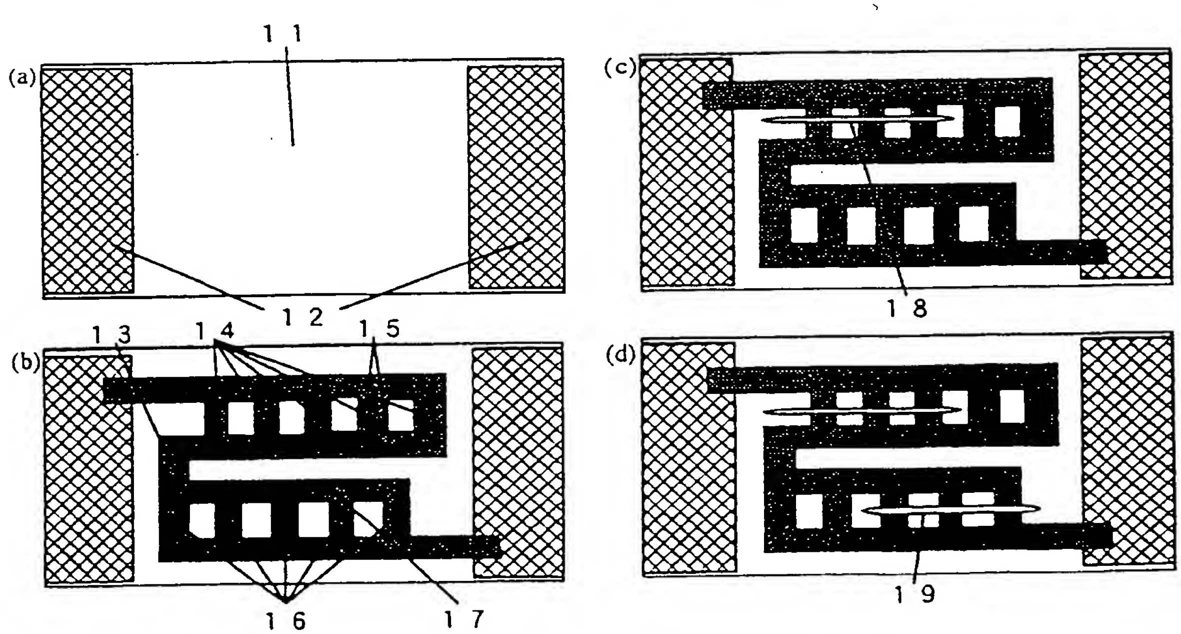


Fig 7

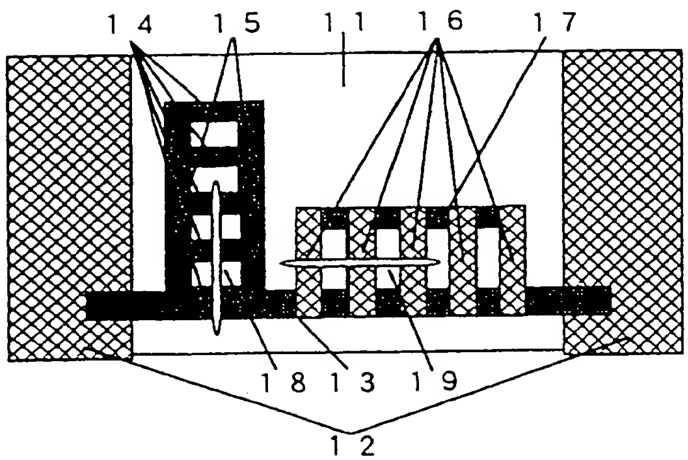
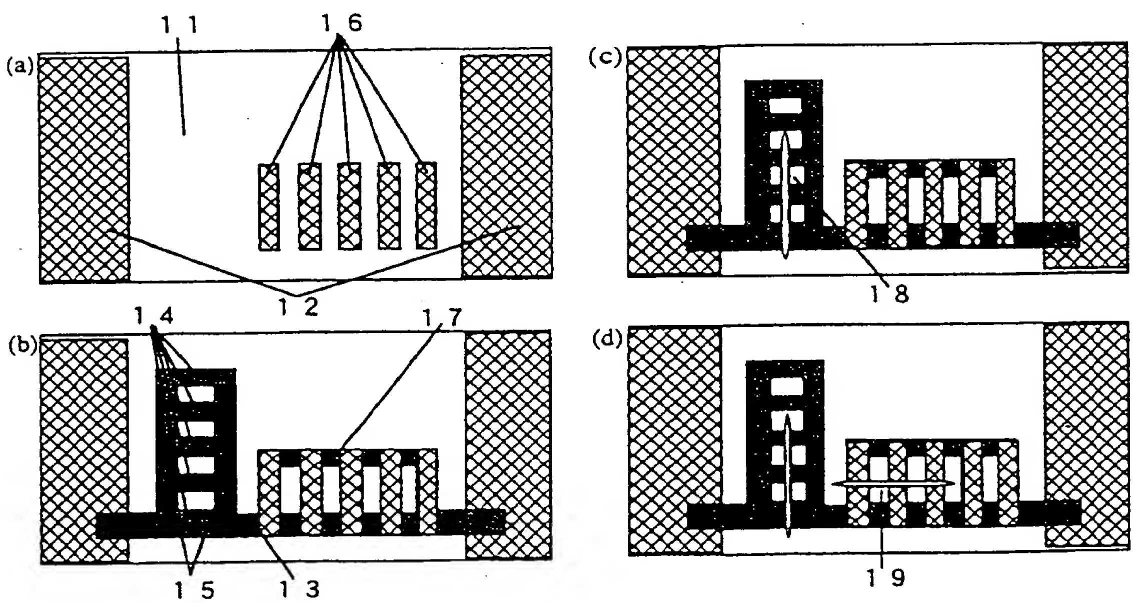


Fig 8



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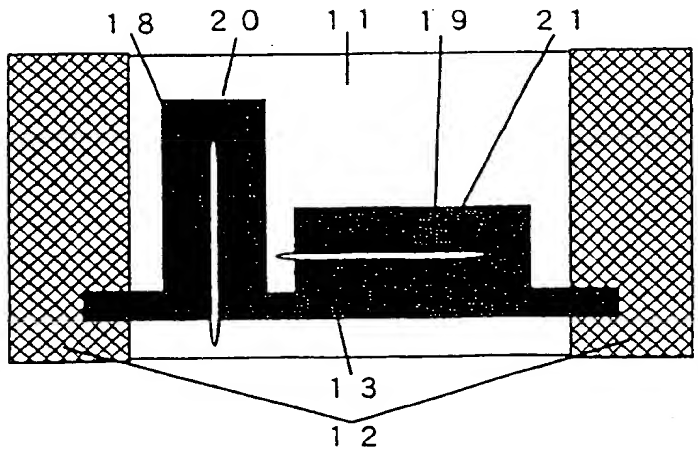

Fig 10

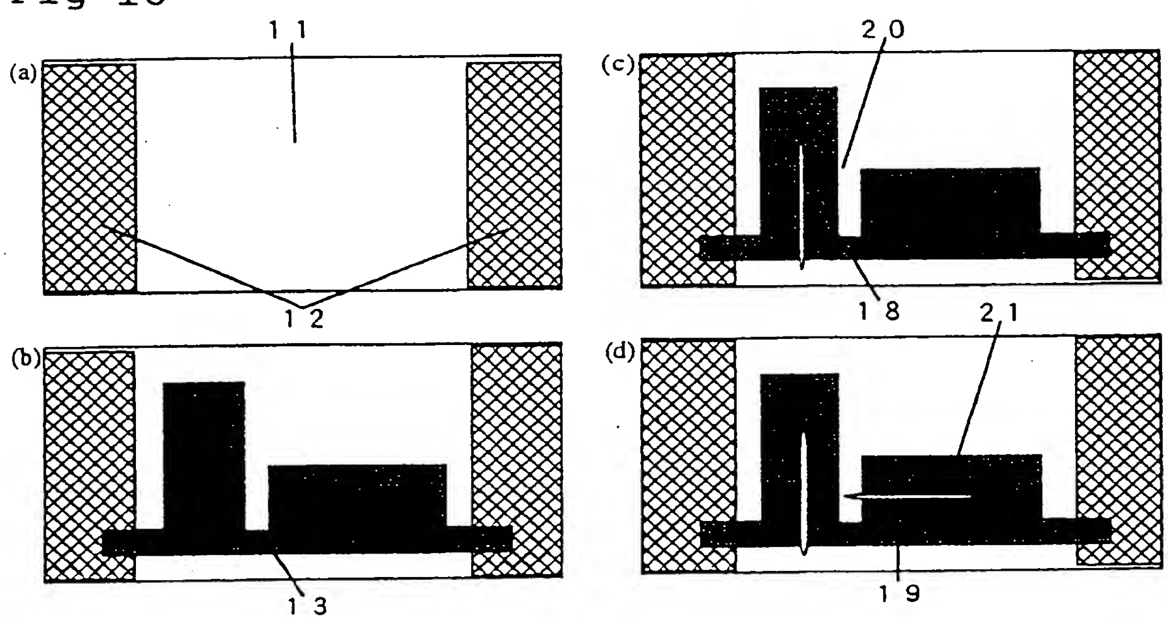

Fig 11

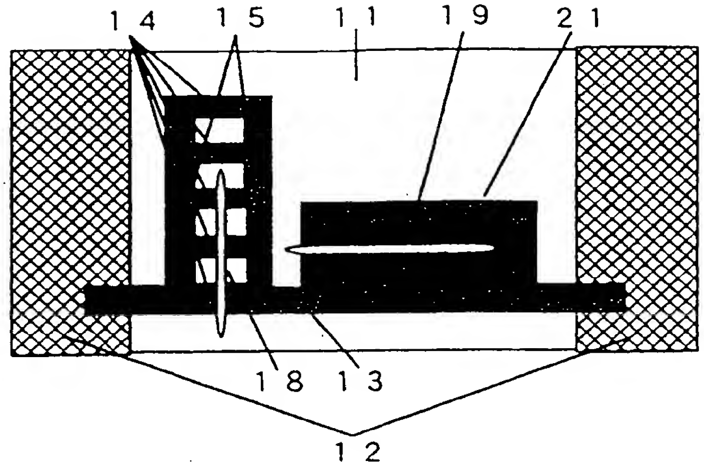

Fig 12

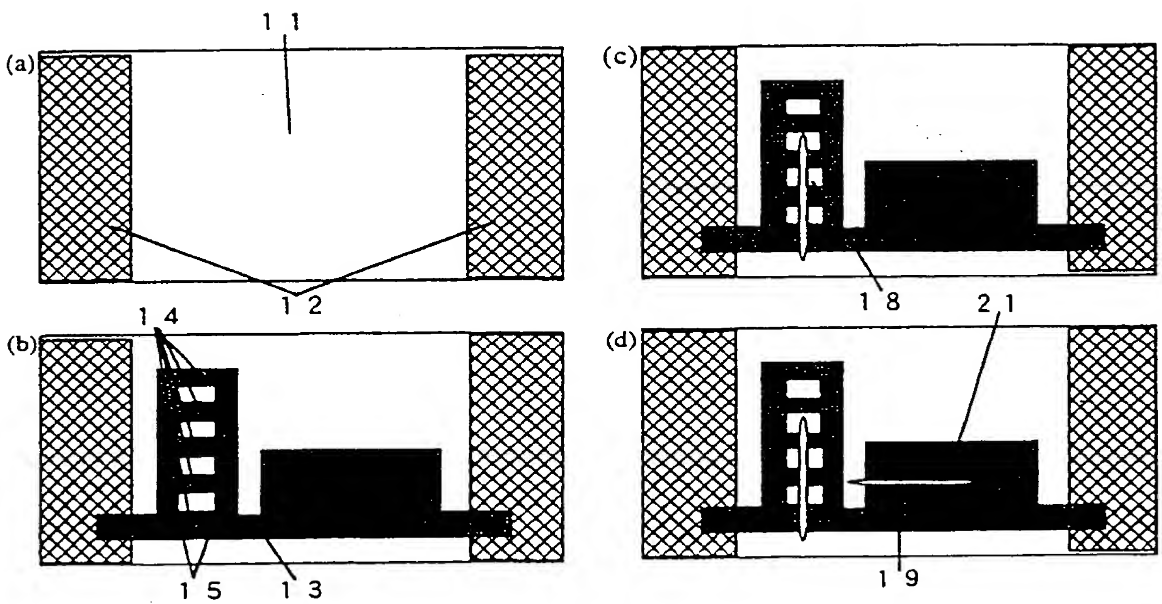

Fig 13

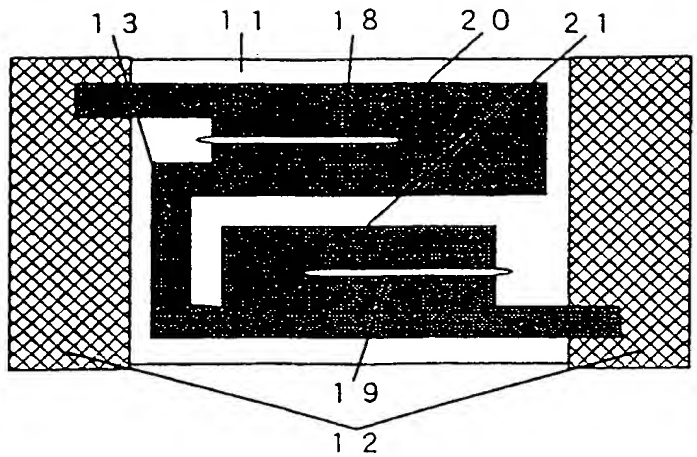

Fig 14

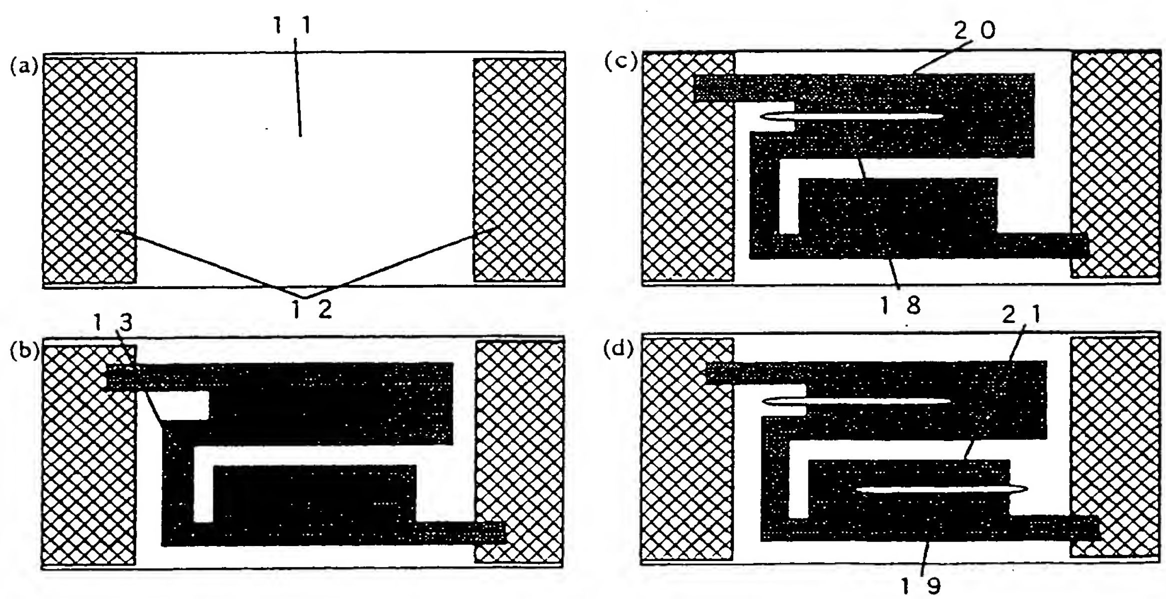

Fig 15

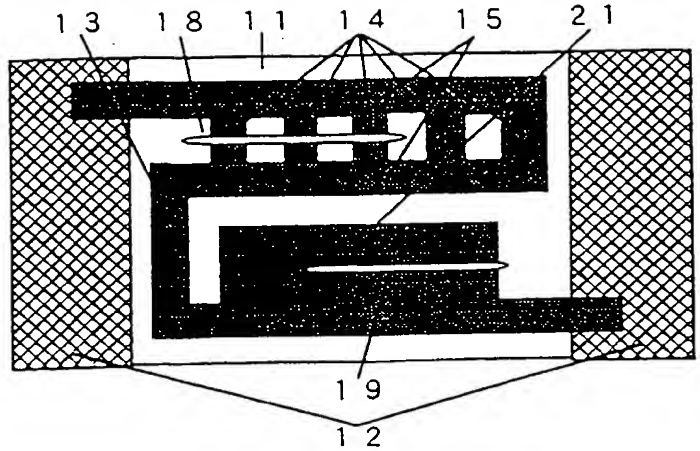

Fig 16

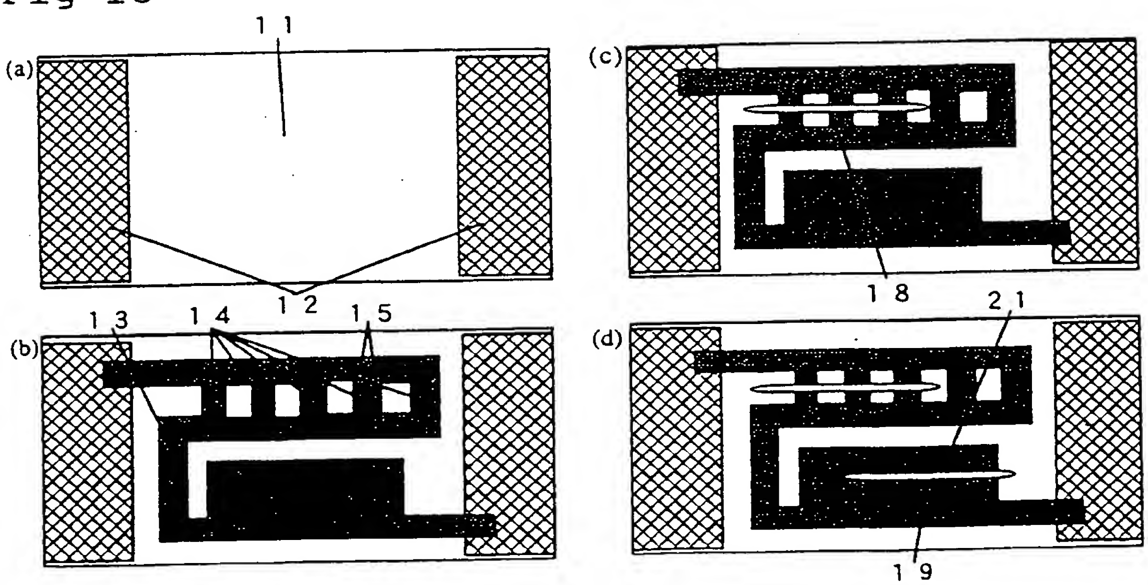

Fig 17

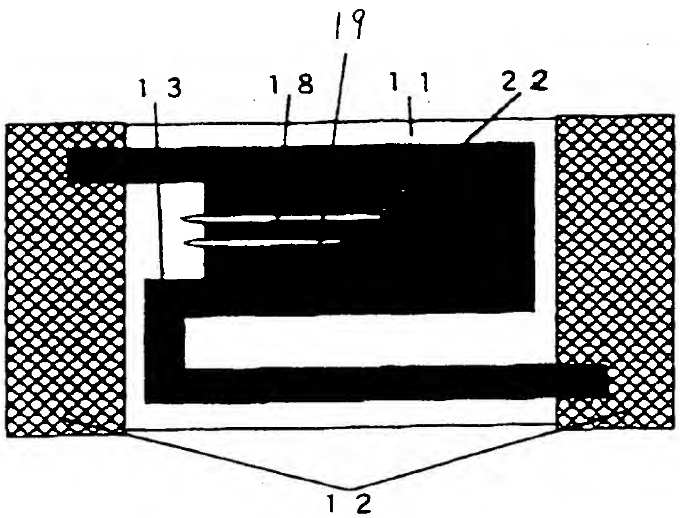

Fig 18

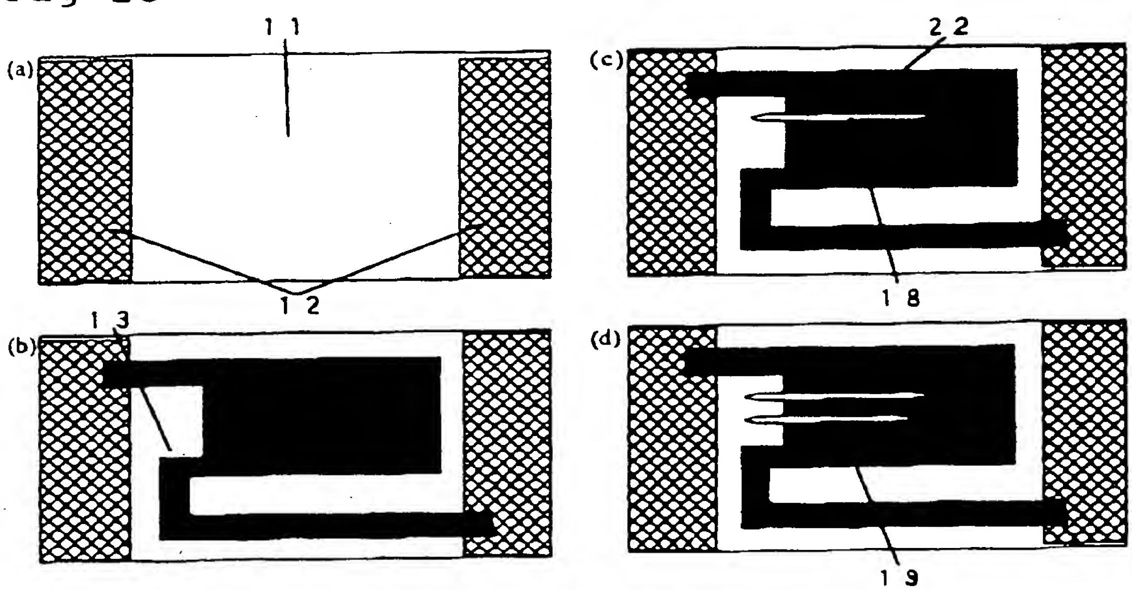

Fig 19